[Third Edition.]

PATENT SPECIFICATION

170,855

Convention Date (Italy): Oct. 25, 1920.

Application Date (in United Kingdom): Oct. 25, 1921. No. 28,344/21.

Complete Accepted: July 20, 1922.

COMPLETE SPECIFICATION.

Valve Gear for Reversing Steam Engines.

I, ARTURO CAPROTTI, of Via Pergolesi 2, Milan, Italy, a subject of the King of Italy, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has for its object a new valve gear for reciprocating steam engines specially adapted for locomotives and wherein the phases of the opening and closing of the admission and exhaust passage-ways are so dependent one on the other that the valve gear satisfies all the conditions theoretically required for the best utilisation of the steam.

Figure 1 to 8 of the accompanying drawings illustrate diagrammatically a constructional form of this invention applied to a locomotive engine.

On the distribution shaft A (see Figures 1, 5, 6, 7 and 8) which rotates at the same speed as the crank shaft, are loosely mounted the cam C which serves only to control (in the forward running of the engine, *i.e.* in the direction of the arrow) the opening of the admission passage-way and the cam C^1 which serves only to control the closing of the same passage-way.

Two rods are connected to each cam, such rods being parallel to the distribution shaft and diametrically opposed. As shown in Figure 1, rods B are connected to the cam C and rods B^1 to the cam C^1. On the same shaft A is a screw V having a multiple thread and quick pitch. Mounted on such screw and in engagement therewith are two grooved sleeves M and M^1 in each of which are formed two holes and two slots, as indicated in Figures 2 and 3.

Through the holes O in the sleeve M pass the rods B, while through the holes O^1 in the sleeve M^1 pass the rods B^1. The latter pass through the slots P in sleeve M, while the rods B, after having passed through the holes O, pass through the slots P^1 in sleeve M^1. The rods B must also pass through the cam C^1 and to allow for this the said cam is provided with suitable slots N^1. The length of these slots is such as to permit a lead of the connected pieces C and M relatively to the connected pieces C^1 and M^1 or *vice versa*; these leads are established so as to regulate the phases of the distribution and their extent is more particularly brought out hereafter.

A third cam D is loosely mounted on shaft A (Figures 1 and 7). Such cam serves for operating the exhaust and its shape is substantially that of an ordinary radial cam. This cam is provided with teeth Z whereby it can be rotated by the teeth Z^1 of the member Q keyed to the shaft A. The said cam is also provided with a slot E into which extend the extremities of one of the rods B and one of the rods B^1.

The shaft A is disposed transversely of the cylinder axis, and mounted parallel to said shaft are axles F (Figures 6 and 7) about which can swing the bell-crank levers G and H, adapted to act respectively upon the admission valves I and exhaust valves S. Such valves are shown as double seat poppet valves, but if desired they can be of any other type.

In order to actuate the valves I, the levers G are each supplied with a rocking beam adapted to swing about the pivot U and having rollers T, T^1 mounted respectively at its ends. The rollers T of the two beams are disposed in a position diametrically opposed and are adapted to

engage with cam C, while the rollers T^1 which are also diametrically opposed, are disposed in another plane and are adapted to engage with the cam C^1, (Figure 8).

The bell-crank levers G are each provided with a third lever arm L and between the ends of these lever arms is placed the spring R by the effect of which the contact between the rollers T and T^1 and their co-operating cam surfaces is ensured. Flanges X, Y, X^1 and Y^1 (Figures 1 and 9) of the sleeves M and M^1 can be operated on by the straps K and K^1 situated in the recesses between such flanges, such straps being displaced in a direction parallel to shaft A by crank pairs W and W^1 on the reversing shaft A^1 and corresponding pairs of connecting rods J and J^1.

The width of the straps K and K^1 is smaller than that of the recesses between the flanges X and Y and X^1 and Y^1 so as to allow of a lost motion between the straps and sleeves.

To the cam D is keyed a cam D^1 (see Figures 1, 5 and 7) which drives an oil circulating pump having a plunger piston and a spring which when compressed serves to return the piston.

The valve gear is represented in the position of the maximum degree of admission in forward running and in this condition the strap K^1 contacts with the flange Y^1, while the strap K is situated equi-distant from both the flanges X and Y, the sleeve M lies adjacent the cam C^1, the rods B of the cam C pass through the slots N^1 of cam C^1 and slots P^1 of sleeve M^1 in the most forward extremity thereof relative to the direction of rotation, and the rods B^1 of the cam C^1 pass through the slots P of sleeve M in the rearward extremity thereof relative to the direction of rotation. Finally, the teeth Z^1 on the member Q fixed on the shaft A act upon the teeth Z on the cam D, in such a manner as to rotate the cam in the direction indicated by the arrow (Figure 7) and as regards the ends of the rods B and B^1, which extend into the slot E, the former is situated at a considerable distance from either of the extremities of the said slot and the second near to the rearward extremity thereof relatively to the direction of rotation indicated by the arrow.

The combined driving of the same admission valve by two distinct cams C and C^1, of which one controls only the opening and the other controls only the closing, is realised as follows:—

The two cams have the same shape, this comprising two circular arcs of equal angular extent but of different radius, connected together at diametrically opposed positions by two connecting curves designed so as to avoid imparting any rude or too rapid change of speed to the levers and to the valves, and each having the angular width of about 40°; each of the rocking beams carrying the rollers T, T^1 can assume four primary positions, and the relative positions of the two cams at the maximum admission degree, as illustrated by the drawings, and the length of the valve stem, are so regulated that the said four positions of each rocking beam follow each other in the following order and with the following results.

1. The roller T is on the curve of smaller radius and T^1 is on the curve of greater radius; the axis U is in its mid position and the valve is closed.

2. The roller T passes on to the curve of greater radius and as roller T^1 remains on the curve of greater radius the pivot U is moved outward relatively to the shaft A and the corresponding valve I is opened.

3. The roller T^1 passes from the curve of greater radius to that of smaller radius and as the roller T remains on the curve of greater radius the pivot U is again moved into the mid position and the valve I closed.

4. The roller T passes from the curve of greater radius to that of smaller radius, both rollers being thus on the curve of smaller radius; the pivot U is moved into its position nearest the shaft A, and the extremity of the horizontal arm of the bell crank lever G will be removed from the end of the valve stem.

From the fourth position the rocking beam returns to the first when T^1 remounts on to the curve of greater radius; the above return takes place at 180° after the passage of roller T^1 on to the curve of smaller radius, which had the effect of closing the valve.

Evidently, these different positions of each rocking beam as aforementioned are not assumed by both these beams simultaneously, but with a difference of phase of 180°, so that while the left-hand beam passes through its successive positions in the order 1, 2, 3 and 4, the right-hand beam passes through the positions in the order 3, 4, 1 and 2. In the position shown in the drawing the crank is supposed to be to the left of the dead centre and the admission valve I of the left-hand port and the exhaust valves of the right hand port are opening. The openings obtained in this position correspond

to the admission lead and exhaust lead of a slide valve gear.

The rotation of the main shaft effects the rotation of the shaft A and the valves are first full opened and then closed and the closing of the admission valve will take place precisely when the roller T^1 passes down the descending connecting curve of the cam C^1 and the exhaust valve will be closed when the roller of the bell crank lever H passes down the descending curve of the cam D.

While the axis of any roller is stationary, as when the roller is engaging with a part of the cam surface which is in the form of an arc of a circle with its centre on the axis of A, any pressure of the roller on the cam will exert a force on the cam purely due to friction, and this has always a tendency to retard the motion of the cam. When however the roller is engaging with one of the connecting surfaces between the two opposed circular surfaces of the cam C, or on the ascending or descending surfaces of the cam D, the said roller exerting a force on said surface will effect a delaying or an accelerating action on the cam according as to whether the surface is approaching or leaving said roller.

For the regular and correct working of the valve gear it is necessary that the accelerating forces shall not exceed the delaying forces. When such a condition is realised then the screw V will always have a tendency to move the sleeves M and M^1 in one direction longitudinally during forward running of the engine and always in the opposite direction during backward running of the engine, and the teeth Z of the exhaust cam will also, during either forward or backward running always tend to keep in engagement with the driving teeth Z^1, and thus any relative movement between the members of the lost motions will be prevented during the normal running of the engine. As regards the admission cams it must be noted that, owing to their shape and to the fact that the two rollers lying on the same cam are diametrically opposed, while the roller corresponding to one of the rods G is moved away from the cam axis, the roller corresponding to the other rod G approaches the said axis; thus, while one of the rollers has a tendency to delay rotation, the other has a tendency to accelerate it. The force with which a roller presses against the cam is proportional to the sum of the moments of the forces acting on its corresponding rod G. These forces consist of the reaction of the spring R, and the upward force due to the closing spring of the valve I and the steam pressure on the valve, if this valve is not perfectly balanced. These two latter forces take place only during the opening and the closing of the valves, *i.e.* in the passage from first to second and from second to third position of the beam, while in the passage from third to fourth and from fourth to first positions, as the rod G does not engage the stem of the valves, the said rod is not subjected to the influence of the valve. So that the resultant actions on the same cam by the opposed rollers shall not be an accelerating force, it is necessary that the difference between the two actions (accelerating force due to one roller and delaying force to the other), shall always be a delaying force, or at least an accelerating force of less value than the delaying force due to friction. If the forces due to friction were such as to just equalize a resultant accelerating action due to the spring, the spring R would only have the effect of maintaining the rollers on the beams in contact with the cams, but as this equalisation is not usually obtained, it is necessary that the spring R should act on the rods G with different effects, according as to whether the rods are under the push of valves or not, so that when a rod G is removed from the valve stem, the spring R acts with a greater leverage on the arm to balance the force due to the stem of the valve on the other rod G. This effect is obtained by the arrangement shown in Figure 6; in the position illustrated, *i.e.* while the left valve I is open and thus pressing on the corresponding rod G, the spring R reacts on both the rods G in the direction of the arrows, but with less leverage on the left rod G than on the right rod. The reverse occurs when the right valve I is open and the left valve I closed.

As the object is not to balance the push of the valves perfectly but only to prevent the accelerating force due to the push of one roller at any moment exceeding the delaying force due to friction or to the push of the other roller, such can easily be obtained by correctly proportioning the maximum and minimum efforts of the spring R and also by suitably proportioning the length of the rods L, and fixing their angular position relatively to the horizontal arms of the levers G. The exhaust cam must not be compelled to accelerate as regards the shaft. The forces on the exhaust cam cannot be balanced in the same manner as for the inlet cams, since, though diametrically opposed rollers are provided, the shape of

the exhaust cam is different from that of the admission cams, for the exhaust period is less than 180°. Under these conditions it is not possible to balance directly the accelerating action of one roller with the delaying action of the other. For this purpose, a second cam D^1 is provided (Figures 1, 5, 7) the shape of which is such that, while one of the exhaust rollers remounts on the cam D, the roller of the oil pump descends on the cam D^1 and while the first roller descends on the cam D, the oil pump roller remounts on the cam D^1, pressing the oil in the pump cylinder and also the return spring of its piston (see Figure 5); as the rollers controlled by the cam D are two in number and diametrically opposed, so the projections of the cam D^1 would be two and opposed. If two oil pumps are provided and diametrically opposed the projection of cam D^1 can be reduced to one. Moreover one of the two pumps could be suppressed if the force of the spring which presses the roller against the cam D^1 were increased in such a manner that the accelerating forces and the delaying of the cam D were balanced (without taking into account the friction's forces) by the delaying and accelerating forces on the cam D^1.

When it is required to reduce the period of admission, the reversing shaft A^1 is turned in the direction of the arrow, so that, while the sleeve M does not move longitudinally (because the strap K has a free movement between the flanges X and Y limited by the play) the sleeve M^1 is moved in a direction away from the admission cams, so advancing the cam C^1 which has the effect of closing the admission valve I at an earlier period.

The dimensions of the various parts of the gear are such that when the period of admission is reduced to 11%, the cranks W have made all their rotation about the dead centre—about 60°, and this corresponds to the play between the strap K and the flanges X and Y of the sleeve M, so that at the end of this movement the strap K contacts with the flange Y. For further reducing the period of admission the sleeve M is also caused to move longitudinally, advancing the cam which controls the opening of the inlet valve and thus producing a condition of back steam. During the movement of the cam C^1 until the period of admission is reduced to the said 11%, the extremity of the rod B^1, which passes through the slot E of the exhaust cam D, advances relatively to the said slot, but as the cam is always rotated by the teeth Z^1 of the part Q, the exhaust will remain the same. When the period of admission is further reduced, however, the extremity of the rod B, which passes through the said slot E and which owing to its connection with the opening cam C has not moved relatively to the slot E, moves with the cam C and therefore advances relatively to said slot, and, owing to the position in this slot which it normally occupies when it has made an advance of 50° relatively to the slot, such rod B corresponding to a back-steam of 27%, the extremity of the rod B contacts with the forward extremity of the slot. From that degree of back-steam to its maximum, when the reversing shaft has been moved to its maximum limit for the regulation, the extremity of rod B will effect the drive of the exhaust cam, which has been advanced an angular distance of about 45°. In this manner the sleeves M and M^1 being longitudinally pushed with the above described play and the exhaust cam D having been moved into its advance position, at the moment of reversing, the sleeves M and M^1 will be exerting no driving action and, owing to the action of the screw V, will be moved longitudinally until they reach the position in which the first lies with its side X against the strap K and the second lies with its side X^1 against the strap K^1 or against the cam D, while the cam D will remain stationary until it is driven in the reverse direction by the teeth Z^1 of the piece Q, acting upon the teeth Z of the cam at the ends thereof opposite to those engaged when driving in the forward direction, or by the extremity of the rod B^1 which extends into the slot E.

Figure 9 represents a form of sleeve for use with a modified system which may be substituted for or used in combination with the lever arms L and the spring R whereby in both directions of running the sleeves M and M^1 are maintained pressed against the two straps K, K^1, or against one strap and the cam C^1 or D, in such a manner that there will always be the maximum of delay in turning such sleeves relatively to the distribution shaft A. As shown in the figure the flanges X and Y^1 respectively of the sleeves M and M^1 are each provided with a side which is undercut, thus having an annular chamber into which can respectively enter, with a little lateral play, the corresponding sides of the straps K and K^1 which respectively push the sleeve M against the cam C^1 (in forward running) or the sleeve M^1 against the cam D (in backward running). The lubricating oil, which

abundantly circulates between the sleeves and the straps, between the annular chambers of the sleeves and the sides of the straps, constitutes an obstacle to the quick entrance of air between the pushing surfaces and consequently to the quick disengagement of the same surfaces. Moreover there is also the adhesion and capillary forces between the polished surfaces, spread with a viscous liquid, which are opposed to a quick separation of the surfaces. Suppose that the spring R and co-acting arms L are substituted by any other system of forces for pressing the axes of the two opposed beams simultaneously against the cams with equal forces, there can only be an accelerating impulse during the closing of a valve; so that only the cam which controls the closing can be under these impulses; thus during forward running only the sleeve M^1 could leave the strap K^1, while in backward running only the sleeve M could leave the strap K. Even at the lower speeds of the locomotive the accelerating impulses are of very short duration, while during all the remaining period of rotation there are some delaying forces (friction or otherwise) so that the pneumatic action and the like as aforesaid are more than sufficient to avoid an advance of the cam C^1 (*i.e.* the moving of the side Y^1 away from the strap K^1) in forward running and an advance of the cam C (*i.e.* the moving of the side X away from the strap K) in backward running. The construction allowing for the play of the parts for effecting the longitudinal displacing of the sleeves and for the advancing of the exhaust cam is necessary in order to obtain a constant lead and an efficient regulation of the exhaust, without special and complicated gearings.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A valve gear for reversible double acting elastic fluid engines having two inlet valves, in which such valves are controlled by two like cams, one of which controls only the opening of such valves during forward running, or only the closing of such valves during backward running, whilst the other cam only controls the opening or closing in the opposite directions of running, such cams being adapted to be moved angularly upon their shaft for regulating and reversing by means of regulating crank mechanism, and in which the actuation of said valves by said cams is effected through the intermediary of two members pivoted intermediate their ends and situated in opposed relation one at each side of the cams, two opposed extremities of such two pivotal members engaging with one cam and the other two opposed extremities of such two pivotal members engaging with the other cam, and each extremity of such members having two positions of rest one position being farther from the axis of rotation of the cam than the other, the arrangement being such that whilst one extremity of one pivotal member passes from one of the two positions to the other, the diametrically opposed extremity of the other member makes the reverse movement, a lost motion device being provided between the regulating crank mechanism and the cams, and provision being made for preventing any relative movement of the members allowed by such lost motion, during the normal running of the engine.

2. A valve gear as claimed in Claim 1 wherein the two pivotal members are each provided at their extremities with rollers or the like to engage with the respective cams.

3. A valve gear as claimed in Claim 1 wherein the angular movement of the operating cams upon their shaft is effected by the regulating crank mechanism through the intermediary of members adapted to be moved longitudinally upon a screw threaded member, the lost motion being provided between such members and associated members positively connected to the regulating crank mechanism, and the means for normally preventing relative movement of such members comprising a spring or the like acting with variable leverage upon arms connected to the pivotal members engaging with the cams, such that the forces tending to accelerate the movement of the cam and thereby tending to effect relative movement between the aforesaid members are balanced.

4. A valve gear as claimed in Claim 3, wherein the spring and the arms on which it acts with varying leverage are substituted by or used in addition to an arrangement whereby pneumatic or capillary actions between the members between which the lost motion is provided tend to prevent relative movement between the same.

5. A valve gear as claimed in any of the preceding claims wherein the exhaust is controlled by a cam acting upon members which actuate the exhaust valves

and which are diametrically opposed relatively to the said cam, such cam being driven either directly by the shaft on which the inlet cams are mounted or through the intermediary of such inlet cams according to the conditions of running, a lost motion device being provided between the cam and each of its driving members and provision being made whereby relative motion between members due to such lost motion is prevented during normal running of the engine.

6. A valve gear as claimed in Claim 5 wherein the means for preventing relative motion between members due to the lost motion consists in the provision of an auxiliary cam rigidly connected to the exhaust cam and acting upon an operating member of an auxiliary mechanism such as the plunger of a circulating oil pump, and upon a return spring or the like in such manner that the force due to the members operated by the cam tending to accelerate the rotary movement of the cam is balanced by forces due to the said members tending to delay such movement of the cam.

7. A valve gearing for reversing and double acting elastic fluid engines substantially as and for the purpose described and as illustrated in and by the accompanying drawings.

Dated this 25th day of October, 1921.

MARKS & CLERK.

Abingdon: Printed for His Majesty's Stationery Office, by Burgess & Son.
[Wt. 95A.—125/4/1932.]

170,855 COMPLETE SPECIFICATION

3rd Edition

SHEET 1

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1

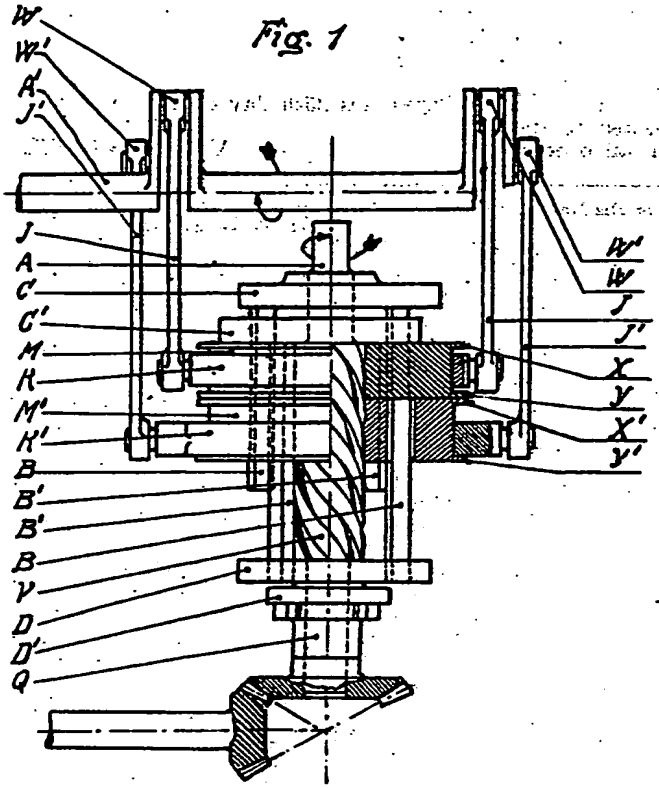


Fig. 4.

Fig. 5

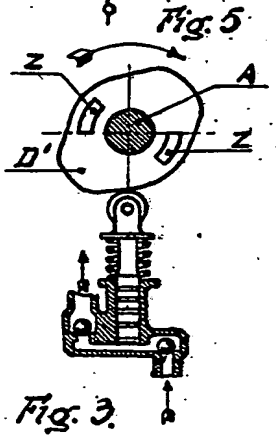


Fig. 2.

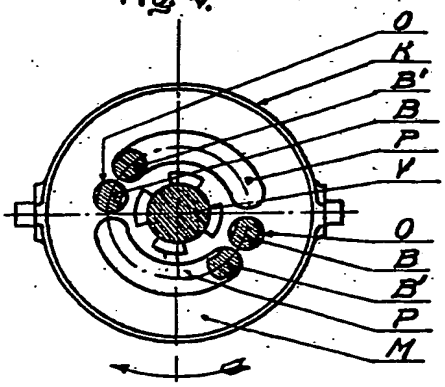
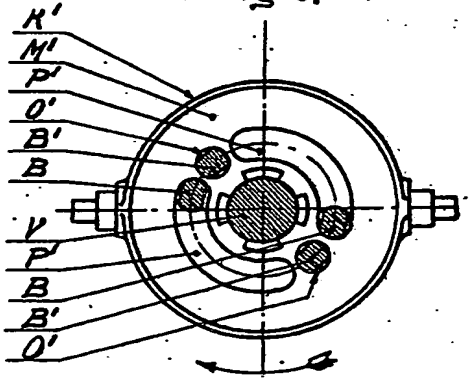
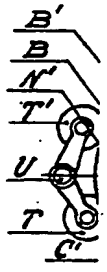


Fig. 3.





170,855 COMPLETE SPECIFICATION

3 rd Edition

SHEET 1

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1

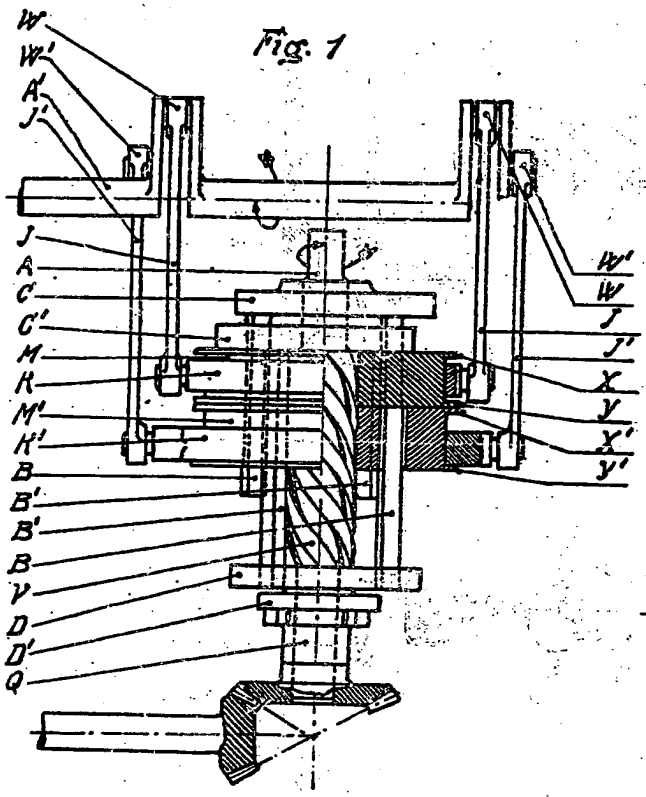


Fig. 4.

Fig. 5

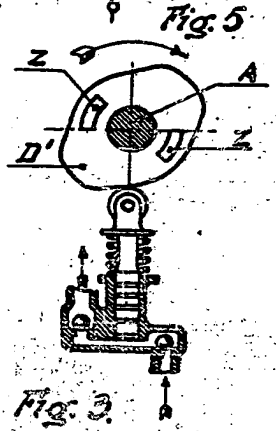


Fig. 2.

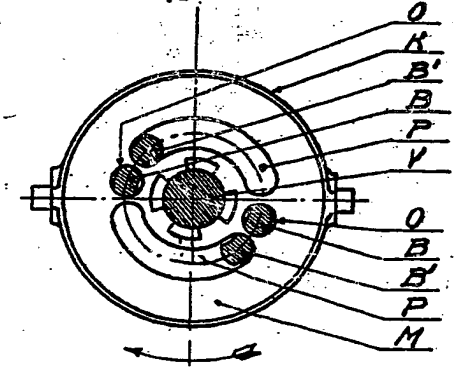
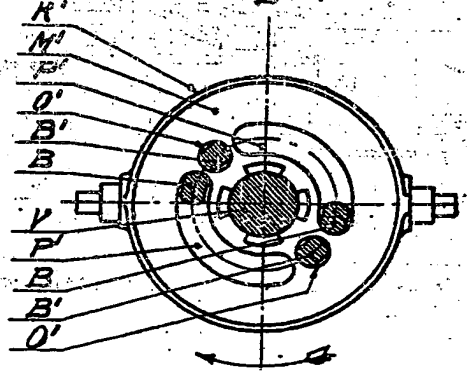
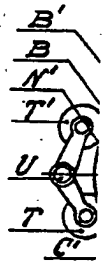


Fig. 3.





170,855 COMPLETE SPECIFICATION

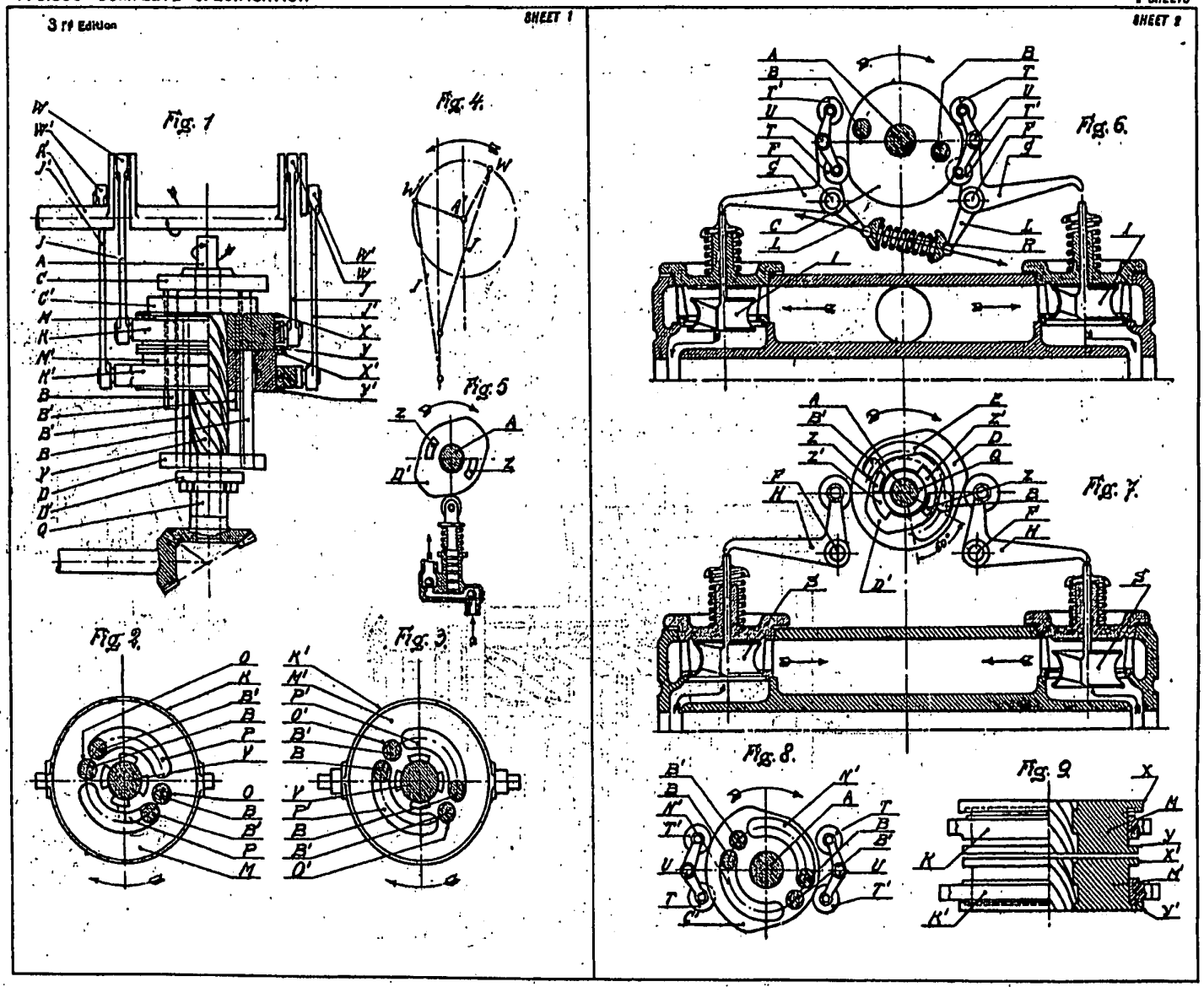
2 SHEETS

3 rd Edition

SHEET 1

SHEET 2

[This Drawing is a reproduction of the Original on a reduced scale.]



Charles & Read Ltd. Photo Litho.

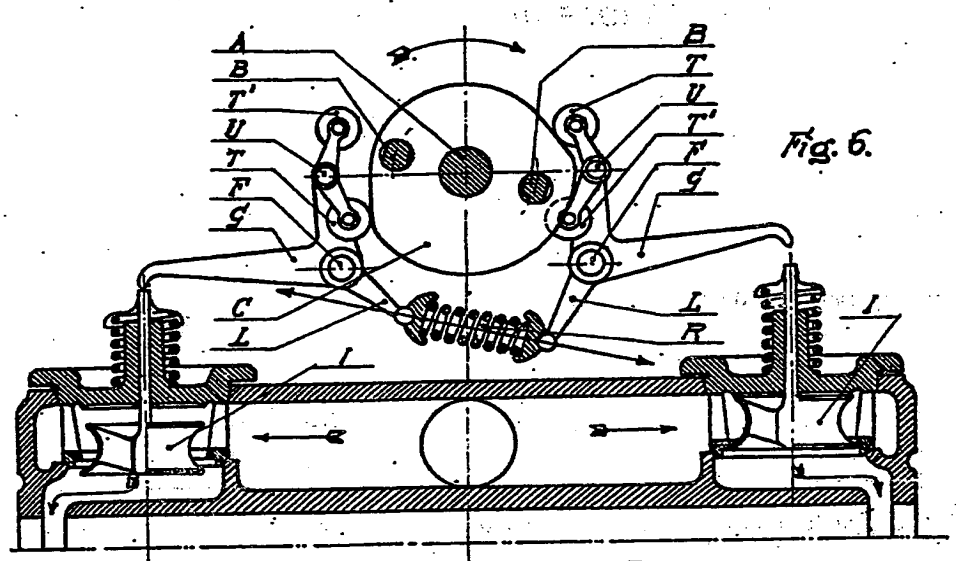


Fig. 6.

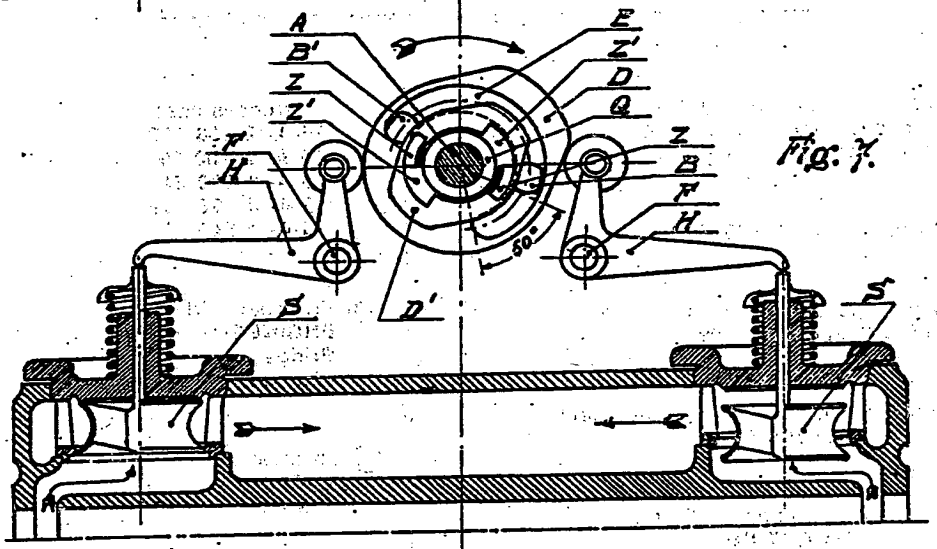


Fig. 7.

Fig. 8.

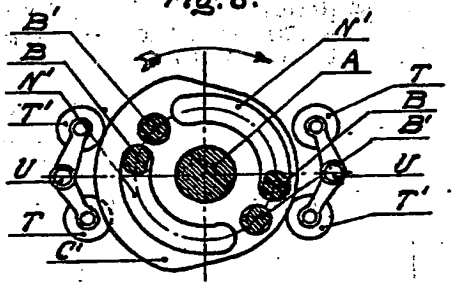
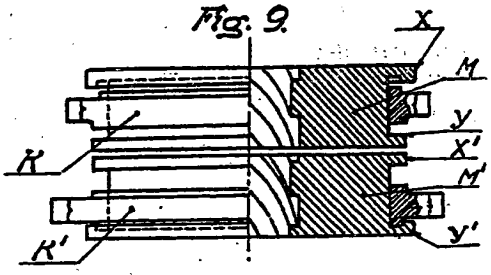


Fig. 9.



Charles & Read Ltd. Photo Litho.